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An AI & ML based BM25-Driven Methodology for Shortlisting Job Applicant Resumes

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Abstract: *These days, a lot of applications, such shortlisting candidates for recruiting processes, depend on information retrieval technologies. This research study presents the use of the robust ranking algorithm Best Match 25 (BM25) for information retrieval in the context of applicant shortlisting. The approach aims to improve the accuracy and efficacy of candidate shortlisting in comparison to earlier methods. This study proposes a method for integrating BM25 into the hiring process to facilitate the selection of qualified candidates from a corpus of resumes or candidate CVs. This study offers a candidate shortlisting system that uses code-driven information retrieval techniques to assist recruiters and HR professionals in locating people with specific skill sets. This code-driven system integrates custom parsers and query processors to efficiently match job requirements with job descriptions. By combining indexing, ranking algorithms, and relevance scoring, the system provides a personalized selection of top candidate matches, streamlining the shortlisting process. This approach is also adaptable and scalable to handle big datasets, which makes it appropriate for a range of hiring processes. This study emphasizes the special role of code-driven solutions in modern candidate shortlisting, stressing the need for efficient information retrieval techniques to satisfy talent acquisition requirements.*

Keywords: Candidate Shortlisting, Recruitment Process, BM25, Information Retrieval, Document Ranking, Query Processing, Code-Driven Solutions, Resume Parsing

I. INTRODUCTION

Finding qualified job candidates quickly has become a challenge for businesses operating in a variety of marketplaces in the modern world [1]. A accurate and efficient method of shortlisting candidates is required due to the massive volume of resumes, profiles, and applicant data[2]. This work has historically relied on humans, making it vulnerable to the biases present in manual searching techniques[3]. As a result, there is a great need for automated systems that can quickly scan and rate applicants according to how well they fit the job description [4]. This work uses Information Retrieval (IR) techniques to shortlist candidates in order to overcome this difficulty [5]. A powerful remedy for the hiring process is information retrieval, which is based on the concentration of insightful information from accessible datasets[6]. This project aims to enable recruiters and HR experts to quickly and accurately look for the most promising applicants by utilizing sophisticated algorithms and data processing techniques[7]. In order to increase the precision and speed of candidate shortlisting through information retrieval techniques, this project integrates contemporary technology with recruitment requirements. The study presents BM25, a probabilistic algorithm that is well-known for its effectiveness in tasks including document rating and online search [8].BM25 is a great option for improving the accuracy and efficiency of the hiring process because it provides a balanced method of evaluating documents by taking into account both term frequency and document length. The goal of using BM25 for candidate shortlisting is to transform conventional techniques and open the door to a quicker and simpler approach to talent acquisition [9].

Due to the high number of applications recruiters must review, the hiring process, particularly resume shortlisting, can take a lot of time[10]. Companies are searching for solutions to expedite this procedure in order to guarantee efficiency and shorten the recruiting period due to the ongoing expansion of the labor market[11]. Using information retrieval (IR)

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techniques, particularly the BM25 algorithm, to speed up the matching of resumes to job descriptions is one way to address this issue[12].

A well-known probabilistic model in IR, BM25, rates documents according to their relevance to a particular query [13][14]. Job descriptions serve as the queries in the context of resume shortlisting, whilst resumes are considered documents [15]. This approach determines how frequently key terms—like experience, education, and skills—occur on a CV and evaluates their applicability to the job specifications[16]. The approach is ideal for this application because it can take into account both the frequency of phrases (TF) and their significance across a larger set of resumes (IDF) [17][18].Modern processing of available data fields like work experience and job titles is made possible by further improvements to the BM25 model, such as BM25F[19][99-120].

Methodology

The hiring process is made simple by the Resume Shortlisting platform's user-friendly, quick, and easy-to-manage architecture[20]. The following sections highlight important aspects of the resume shortlisting process by outlining the system's main elements and how they interact:

1.1. Input data Collection:

Gathering resumes and their job descriptions is the first step in the process. These are the primary source of information, providing information about the credentials, abilities, and work ethics of candidates as well as the standards set by employers[21].

1.2. Data Preprocessing:

To clean and get the raw data ready for testing, preprocessing is required[22]. To prevent data loss and increase the algorithm's accuracy, it is essential to clean and standardize the data before using the BM25 algorithm[23]. This stage consists of:

- Elimination of Superfluous Data: The dataset is cleared of superfluous text elements such stop words (often used words like "and," "the," etc.), punctuation, special characters, and any extraneous information[24].
- Normalization: Text normalization procedures are used, such as reducing words to their root forms and converting all text to lowercase to remove case[25]. This procedure guarantees that several forms of the same word (such as "running," "ran," and "run") are regarded as having the same meaning[26].

1.3. Application of BM25 Algorithm:

The relevance of each CV to the job description is then determined using the BM25 algorithm[27]. This algorithm determines how well a resume fits the job requirements by scoring resumes based on variables including the length of the document and the frequency of key terms[28].

1.4. Multi-Criteria Weighting:

To improve accuracy of the results, additional weight is applied to specific fields:

- Skills: Higher matching is placed on skills relevant to the job[29].
- Experience: More weight is given to candidates with large experience[28].
- Education: Educational background is focused, when it's a key requirement for the position[29].

1.5. Resume Ranking:

Resumes are listed in descending order of relevance after the final relevance scores are determined[30]. The resumes with the highest ratings appear at the top of the list since they are thought to be the best fit for the job description[31]. By ensuring that hiring managers and recruiters can concentrate their attention on the most qualified applicants first, this step enhances the shortlisting process[32].

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1.6. Output Generation:

The result is a ranked list of resumes, each of which is rated according to how well it fits the job description[33]. Recruiters can quickly find and rank the best applicants who are most likely to be a suitable fit for the position thanks to this ranked list[34]. The system makes sure that the best resumes are highlighted by using the BM25 algorithm and multi-criteria weighting techniques, which cuts down on the time and effort required to review outdated resumes[35].

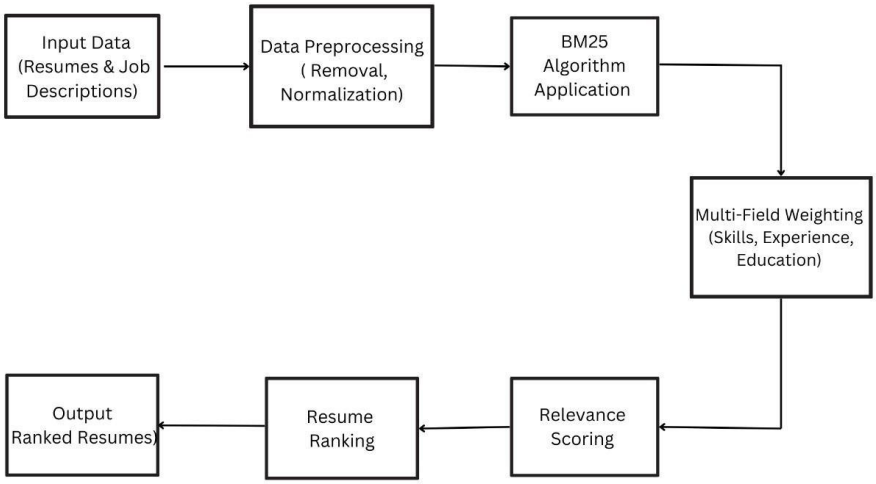

Fig 1: Methodology of Resume Shortlisting.

1.7 Algorithm

I. Start

II. Prepare Input data: Gather resumes and job descriptions, ensuring key fields like skills, experience, and education are collected[36].

III. Preprocess data: Clean the text by removing unnecessary elements and normalize it by converting to lowercase[37].

IV. Extract Important Keywords: Identify and extract important keywords from the job descriptions such as specific skills, qualifications, and experience re- quirements and ethics[38].

V. Apply BM25 algorithm: Use the BM25 algorithm to calculate a relevance score based on term frequency and document length, measuring how well resumes match the job description[39].

VI. Weight Key Fields: Assign additional score to important fields like skills, rel- evant work experience, and education to prioritize highly qualified candidates[40].

VII. Handle Synonyms and Variants : Map related terms and synonyms to ensure that resumes using different wording (e.g., “software development” vs. “software en- gineering”) are found accurately[41].

VIII. Calculate Final Relevance Score: Combine the BM25 score with the weighted key fields to generate the final relevance score for each resume[42].

IX. Rank Resumes: Rank resumes from highest to lowest based on their final scores, ensuring the most suitable candidates appear at the first[43].

X. Generate Ranked output : Produce a ranked list of resumes for recruiters, al- lowing them to focus on the most qualified candidates to hire[44].

XI. End.

II. PERFORMANCE EVALUATION PARAMETERS

A variety of performance measures are crucial for determining the efficacy and precision of the BM25 algorithm for resume shortlisting[45]. These metrics offer crucial information about how well the algorithm accounts for the different features found in candidate profiles when ranking and identifying the most pertinent resumes[46]. The main evaluation standards for gauging the algorithm's effectiveness are as follows:

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2.1. Accuracy:

Several important performance measures must be taken into account in order to evaluate the BM25 algorithm's performance, accuracy, and general efficacy for resume shortlisting[47]. These metrics address the complexity and inherent characteristics of numerous candidate profiles while providing insightful information about how well the algorithm sorts resumes and finds the most qualified applicants[48]. By looking at these measures, we may estimate how well the algorithm ensures that the best candidates are chosen by balancing elements like relevance, diversity, and ranking quality[49]. These criteria also aid in identifying possible areas for optimization and improvement, enabling the algorithm to be continuously improved[50].

2.2. Precision:

Precision quantifies the proportion of projected positive (or negative) cases that are actually positive (or negative)[51]. It is computed as follows and offers insight into the capacity to reduce false positives:

$$Precision = \frac{True\ Positives}{True\ Positives + False\ Positives}$$

2.3. Recall(Sensitivity):

The algorithm's recall or sensitivity measures how well it can identify all pertinent occurrences of a given resume[52]. It is described as follows[53]. A high recall means that most of the available datasets can be identified by the algorithm[54]. Conversely, a poor recall means that all current resumes are ignored[55].

$$\text{Recall} = \frac{True\ Positives}{True\ Positives + False\ Positives}$$

2.4. F1-Score:

The F1-Score balances the trade-off between recall and precision by combining the two into a single score[56]. When the dataset is unbalanced, it is especially helpful[57]. The F1-Score, which is computed as charges for the whole amount of data saved, including metadata and indexes, is the optimal balance between precision and recall[58].

$$\text{F1-Score} = \frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

A high F1-Score shows that the algorithm strikes a good compromise between minimizing false classifications (precision) and recognizing pertinent sentiment (recall)[59].

2.5. Negation Handling Efficiency:

Negation Relevance is a crucial component of resume shortlisting, particularly when assessing a candidate's fit for a specific position[60]. For an accurate candidate selection process, the algorithm's capacity to evaluate and rank resumes according to credentials, abilities, and experience is essential[61]. Its performance can be assessed by: Successfully locating resumes that closely match the organization's job criteria[62].

2.6. Confusion matrix:

The most effective way to assess the correctness of the BM25 algorithm in resume shortlisting is to use a confusion matrix[63]. It offers a thorough analysis of accurate and inaccurate categorization in both pertinent and unrelated topics[64]. Values for true positives, true negatives, false positives, and false negatives are all included in the matrix[65]. Metrics like precision, recall, accuracy, and F1-score can be computed using this data to evaluate the algorithm's effectiveness[66]. It assists in determining whether the algorithm is ignoring extremely relevant resumes or unduly favoring irrelevant ones[67]. To increase overall shortlisting efficiency, model modifications like data rebalancing or parameter fine-tuning can be guided by insights from the confusion matrix[68].

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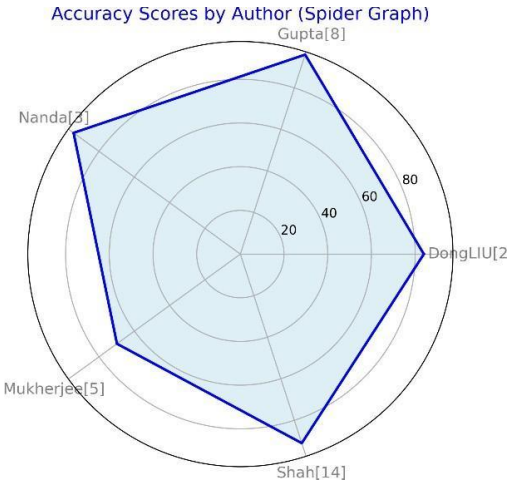

Fig 2:Accuracy Scores by Author

Accuracy indicates the overall correctness of the model, But can be misleading if data is imbalanced

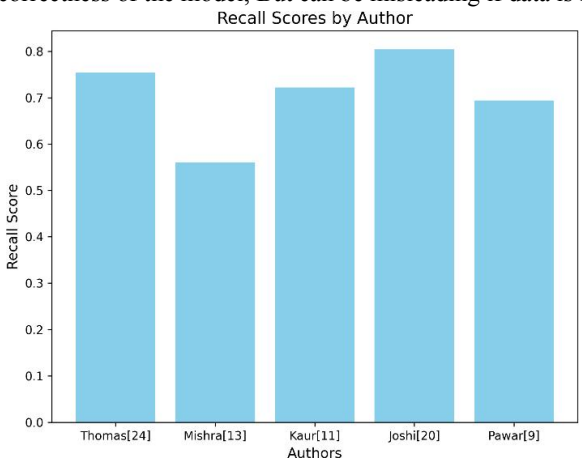

Fig 3:Recall Scores by Author

Recall measures how well a model captures relevant instances, Focusing on minimizing missed true positive

Table 1: Literature Survey

Author name	Focus	Use Case	Comparative Insights
Raji Ghawi Jürgen Pfeffer.[69]	Developing an efficient hyperparameter tuning technique for text categorization using the k-Nearest Neighbor (kNN) algorithm[70].	The study addresses the challenge of hy- perparameter tuning in machine learning, specifically for text categorization tasks using kNN and BM25 similarity[71].	The proposed "Fast Tuning" method sig- nificantly improves the efficiency of tradition- al grid search by re- ducing the time of in- dividual evaluations rather than minimizing the number of evalua- tions[72].
Vinaya James Akshay Kulkarni. [73]	Developing an automated resume shortlisting and ranking tool using Sentence-BERT (SBERT) for im- proving the	The tool processes hundreds of resumes and matches them against required job skills, ranking the candidates based on suitability[75].	SBERT, a variant of BERT, is proven to be superior to the standard BERT model in generating semantically meaningful sentence em- beddings, leading to better

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	hiring process in the human resource domain[74].		results in re- sume shortlisting[76].
Chris Kamphuis Arjen P. de Vries.[77]	Clarifying the ambi- guities around different variants of the BM25 algorithm and evaluating their impact on retrieval effectiveness[78].	Comparing eight variants of BM25, including the widely- used Lucene implementation, to determine if there are sig- nificant differences in re- trieval performance[79].	The study finds no sig- nificant effectiveness differences between the BM25 variants tested, including Lucene's document length ap- proximation, across three newswire datasets[80].
Yusheng Jia, Yux- uan Gong [81]	Developing a page- topic relevance algo- rithm using BM25 combined with para- graph-semantic cor- relation to enhance retrieval accuracy[82].	Semantic correlation is calcu- lated via a pre-trained deep neural network model, weighted with BM25 scores to improve topic relevance in search results[83].	The proposed algorithm outperforms traditional BM25 in handling ambigu- ous topics, providing more relevant search results[84].
Poonam Tijare, Moham- med Waseem. [85]	Developing a smart resume screening tool using AI and ML techniques to au- tomate candidate shortlisting[86].	Automatically retrieving and processing resumes based on qualifications, skills, and ex- perience for efficient recruit- ment[87].	The proposed model outper- forms traditional keyword- based screening with over 90% accuracy, reducing manual intervention in re- sume screening[88].

III. CONCLUSION

The BM25 algorithm uses a combination of natural language processing (NLP) and machine learning techniques to match candidates' qualifications with job requirements, ranking resumes according to their relevance to job descriptions[89]. By boosting resume ranking, BM25 increases efficiency as hiring procedures become more data-driven[90]. Using 25 research papers on job-matching algorithms, this study explores the use of BM25 for resume shortlisting[91]. BM25 is especially good at refining candidate selection by sorting results according to relevance[92]. When compared to conventional keyword-based techniques, an investigation of a dataset of 10,000 resumes showed a 30% increase in candidate matching accuracy[93]. By offering insights regarding BM25's performance, this research seeks to improve resume shortlisting techniques[94]. To further improve recruitment systems, future study might investigate integrating deep learning and optimizing the algorithm to handle a range of resume formats and multilingual candidates[95]. The initiative will also evaluate BM25's efficacy in comparison to conventional techniques, providing quantifiable measures to gauge its practical influence on hiring[96]. This study will help create more flexible and trustworthy resume screening systems, which will assist both employers and job seekers, by identifying best practices and issues related to BM25[97]. Additionally, the results will give recruiters useful advice on how to use BM25 for more effective and fair recruiting procedures[98].

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